

SOIL SURVEY OF THE GRAND FORKS AREA NORTH DAKOTA.

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LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed is situated in Grand Forks County, one of the eastern tier of counties of North Dakota, lying a little north of the east and west medial line. The eastern limit of the area is the Red River of the North, which also forms the State boundary line.

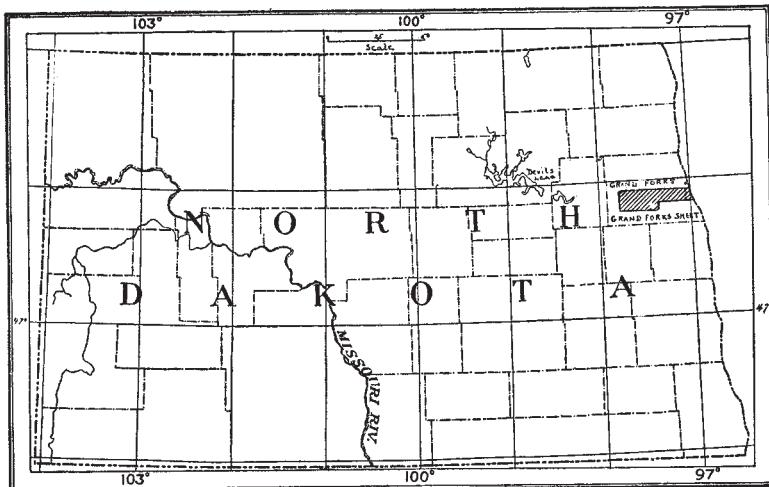


FIG. 19.—Sketch map showing area surveyed in North Dakota.

Grand Forks, in the northeastern part of the area, is situated in about north latitude $47^{\circ} 55'$ and west longitude $97^{\circ} 05'$. The area extends a distance of 34 miles west from that town. For the first 15 miles the area is 6 miles wide, and for the remaining 18 miles it has a width of 12 miles. The area includes T. 151 N., Rs. 50 to 55 W., inclusive, and T. 150 N., Rs. 53 to 55 W., inclusive, and covers an area of 314 square miles or 200,960 acres. Probably most or all of the types of soil in the county occur in the area mapped. (See fig. 19.)

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The Dakotas were originally a part of Michigan, Wisconsin, Iowa, and Minnesota, and during the years between 1834 and 1858 the boun-

daries were often changed. Civil government of the Dakotas did not begin until 1861, and North and South Dakota were not constituted separate States until 1889.

British and American fur companies were the first to occupy Dakota Territory, and land was not taken up for agricultural purposes until 1851, when a few white settlers obtained a few hundred acres from the Sioux Indians. Agricultural pursuits were, however, often interrupted, even at this late date, by the Indians, who a number of times drove the settlers out of the country.

Grand Forks County was created June 4, 1873, from part of Pembina County. Its boundaries were changed in 1875, in 1881, and again in 1883. The first settlement in the county was Grand Forks, the county seat, which was established late in the seventies. What was but an aggregation of a few houses in 1879 is now a thriving town of 8,000 or 9,000 inhabitants. Agricultural development at that time was limited to a few isolated ranches, as there were no railroad accommodations so far north until 1880-81, when the Great Northern Railway was built through Grand Forks westward. Agricultural development was very rapid along the main line of this road and branches were soon built which gave greatly increased shipping facilities and resulted in a great impetus to farming in various parts of the county and State.

The increase in improved farm lands has, however, been greatest during the last decade, within which time the number of farms and the value of improvements have almost doubled. Much of the western part of the county is not yet improved or developed, being somewhat hilly and less desirable generally than the eastern part.

CLIMATE.

The climate of the Red River Valley may be classed as subhumid. The annual rainfall, which is approximately 20 inches, is usually so distributed as to furnish enough moisture for crop purposes during the growing season. Occasionally, however, a season of drought occurs when crops are practically a failure. The year 1902 was very favorable as regards moisture, but the spring season was late and in a few instances cereals could not be planted in time to mature. The summer months are warm without being uncomfortable, and the fall months cool—conditions required for the proper maturing of the hard variety of wheat grown.

Hailstorms sometimes do considerable damage, and a few of these occurred in various parts of the State in 1902. A small section of the county sustained damage in July by a hailstorm, the force of the wind being sufficient to upset a few houses and telegraph poles.

The wind movement is comparatively high, especially during the

fall of the year. It is sometimes strong enough during the summer months to badly damage heavy grain, especially if the wind is accompanied by rain, as sometimes happens.

The following table shows the normal monthly and annual temperature and precipitation, taken from Weather Bureau records:

Normal monthly and annual temperature and precipitation.

| Month. | Larimore. | | University. | |
|-----------------|-------------------|---------------------|-------------------|---------------------|
| | Temper- ature. | Precipi- tation. | Temper- ature. | Precipi- tation. |
| January | 4.0 | 0.91 | 4.0 | 0.55 |
| February | 5.0 | .31 | 6.0 | .51 |
| March | 17.0 | .55 | 19.0 | .62 |
| April | 41.0 | 1.47 | 41.0 | 2.88 |
| May | 53.0 | 2.54 | 54.0 | 3.14 |
| June | 60.0 | 3.68 | 63.0 | 4.32 |
| July | 66.0 | 3.35 | 67.0 | 1.96 |
| August | 64.0 | 1.97 | ..... | 1.94 |
| September | 56.0 | .61 | 56.0 | 1.12 |
| October | 42.0 | .79 | 42.0 | .76 |
| November | 22.0 | .36 | 22.0 | .76 |
| December | 18.0 | .75 | 10.0 | .62 |
| Year | 38.0 | 17.25 | ..... | 19.64 |

PHYSIOGRAPHY AND GEOLOGY.

The topography of the area is very simple. The level alluvial area extends from Grand Forks west to within about 2 miles of Emerado. The slope of this area is less than 1 foot to the mile. From there westward to the glacial drift there are 8 or 10 beaches or ridges with a northwest and southeast trend, varying in height from a few feet to perhaps 40 or 50 feet, though the latter height is seldom attained in the area surveyed. These ridges are from one-half mile to 2 or 3 miles apart and have very gentle slopes. Often shallow swales extend from one beach to another. Sometimes the beaches form plateaus.

From the Herman beach westward as far as the area surveyed extends there is a rise of perhaps 100 to 200 feet. This is the glacial drift area and consists almost entirely of small hills and hollows or swales scattered about indiscriminately. The individual hills are not extensive in area and vary from 10 feet to 60 or 70 feet in height, with slopes generally not too steep for cultivation.

There are many glacial boulders scattered about these hills and in the whole of the western part of the area surveyed. These occur in small masses or singly, and some of them are of enormous size. They are, however, not numerous enough to interfere seriously with cultivation.

There are a number of stream courses, a few deep but most of them shallow, traversing the area in a general easterly direction. With few exceptions these are dry during the greater part of the year.

The area surveyed includes a part of the bed of glacial Lake Agassiz, and extends from Red River (approximately the middle of the valley) to and slightly beyond the upper or western beach of the lake into the glacial drift. The area thus traverses the lacustrine deposits in the middle of the valley, the bench lands and beaches westward, and the upper beach of the lake. The extreme western limit of the area extends several miles into the glacial drift, which corresponds to Fargo gravelly loam. The altitude of Grand Forks is 830 feet above sea level.

The upper beach, several miles west of Larimore, known as the Herman beach, marks the western limit of the lake, while from there to several miles east of Emerado is a series of smaller beaches, representing various temporary stages of the lake during its recession. There are smaller unimportant beaches between Ojata and Grand Forks. These beaches consist of sandy loam, sand and gravel, and reworked till, the surface soil being invariably sandy loam, generally gravelly. Some portions of these beaches, especially those near the western limit of the lake, closely resemble eskers. These beaches were undoubtedly formed by the action of the surf of the lake while its waters remained at one level for longer or shorter periods, in the same manner that beaches are formed at present along the shores of existing bays and lakes. The formation of the beaches was also assisted by the débris continually being unloaded by the floating ice. The coarser material would thus be washed up along these beaches and the finer particles, with occasional pebbles, would settle in the swales between them.

Small kettle holes are quite numerous in the western part of the area and more rarely in the eastern.

The alluvial clay proper, or as classified during the survey, Miami black clay loam, does not appear along the main line of the Great Northern Railway until a point about 2 miles west of Ojata is reached, while west of this the surface soil is sandy loam with a clay or clay loam subsoil. The alluvial silty loam, grading into clay or clay loam at a few feet below the surface, varies considerably in depth and at Grand Forks is probably from 50 to 75 feet deep. This stratified alluvial deposit is underlain by glacial till or drift, which gradually approaches the surface westward, forming the subsoil of Fargo gravelly loam and finally outcropping a few miles west of Larimore as a beach. At Fargo the drift has a thickness of 150 feet. Under this drift is found cretaceous shale, probably the Niobrara and Fort Benton. It has a thickness at Grand Forks of over 300 feet. This is in turn underlain, at a depth of 385 feet at Grand Forks, by granite and gneiss which extends to an unknown depth.

Over a large part of the area, especially in the west, large boulders of granite, gneiss, and more rarely limestone are found in local masses, having been dropped by the floating ice. A large number of local beds of crystalline gypsum were found at a depth of from 1 to 6 feet below the surface. Apparently similar beds were also found in the glacial drift.

As gypsum beds are found almost invariably in the slight local rises or ridges in the alluvial soils, and as the texture of the soil in those places is lighter than the surrounding soils, it would appear that these beds are due to gypsum and accompanying salts being dropped there by the floating ice. Against this theory may be urged the fact that boulders are not found in or around these local rises. Boulders of fair size are, however, found at a considerable distance east of Ojata, and as gypsum has a lighter specific gravity than granite or limestone, there would at least be a chance of its being carried farther by the smaller floating ice masses. Moreover, the lake must have been comparatively shallow at the time these gypsum beds were laid down, for over some of them there is less than a foot of soil. With the lake at a low stage it would be impossible for large ice masses carrying great boulders to drift so far eastward.

SOILS.

Five types of soil were recognized in the area surveyed: Fargo gravelly loam, Miami sandy loam, Fargo loam, Miami loam, and Miami black clay loam. Besides these types a number of small areas of muck were mapped.

The texture of the surface soils in the eastern part of the area is as a rule heavier than in the western, the difference being due to the difference in origin. Those in the eastern part of the area are of direct alluvial origin and are loams or clay loams, while those in the western part have been more or less modified by the action of the shore water of the ancient lake and by drift and are consequently lighter in texture.

Areas of different soils.

| Soil. | Acres. | Per cent. | Soil. | Acres. | Per cent. |
|-----------------------------|--------|-----------|-----------------|---------|-----------|
| Miami sandy loam | 68,800 | 34.3 | Fargo loam..... | 12,352 | 6.1 |
| Fargo gravelly loam | 51,136 | 25.4 | Muck | 6,592 | 3.3 |
| Miami black clay loam | 44,352 | 22.1 | Total..... | 200,960 | ..... |
| Miami loam..... | 17,728 | 8.8 | | | |

FARGO GRAVELLY LOAM.

The Fargo gravelly loam, occupying, as typically developed, the extreme western limit of the area, consists of from 1 to $2\frac{1}{2}$ feet of loose black sandy loam with small gravel disseminated through it vary-

ing in size from very small particles to pebbles about one-half inch in diameter. The surface is also generally gravelly, though over large areas this feature is absent. The surface soil is underlain to a depth of about 3 feet by a black or gray gritty loam, which is in turn underlain by gritty, stiff white or yellow, or mottled gray and yellow loam, containing small gravel and frequently small concretions of iron oxide. This material often grades into clay loam or clay at a depth of 5 or 6 feet. Local beds of crystalline gypsum are often found at a depth of 2 or 3 feet. Over the surface are scattered local masses of glacial bowlders of granite, gneiss, schists, and limestone, but these are not numerous enough to seriously interfere with cultivation.

The topography is undulating, consisting of small irregular hills or knolls of small surface area varying in height from about 10 feet to 40 or 50 feet. Between these are shallow depressions in the shape of swales or kettle holes. The slopes of these hills are not steep and with very few exceptions are easily cultivated. The soil on their summits is lighter in texture than that of the intervening hollows and contains considerable gravel, while the surface soil in the depressions is often very mucky, though not sufficiently pronounced to be classed as muck.

This type is well drained, with the drainage eastward, and many shallow and a few deep creek depressions traverse it, the majority of which, however, are dry during the greater part of the year.

A few local alkali spots were found in this soil, but none of great enough extent to show on a map of the scale used. The clay and clay loam subsoil generally carry some and often considerable alkali, but this does not lie near enough to the surface to interfere with plant growth. The subsoil often carries a very large amount of lime, and when mixed for tests in alkali determinations it gives off a strong mortarlike odor. The lime is probably due to limestone which has been crushed and ground by the ice, as small gravel of this rock of all sizes is scattered through the soil.

The Fargo gravelly loam is largely composed of glacial till or drift, though in the eastern limit of the type the material has been reworked by the wave action of the ancient lake. The soil there gives evidence of having been considerably washed, and hence there is much more gravel and the interstitial soil is lighter than in the area farther west.

This soil is generally adapted to wheat, oats, and barley, and during seasons of favorable rainfall good yields of these crops and of flax can be produced. The soil on the higher elevations does not, however, retain moisture well and is apt to be affected by drought.

Much of this type is still unbroken and unimproved, and such areas bear a splendid growth of prairie grass and would be excellent for grazing range stock.



ONE OF THE EXTENSIVE WHEAT FIELDS OF THE RED RIVER VALLEY, GRAND FORKS AREA, NORTH DAKOTA.
The lands are under an extensive system of farming and the yield does not exceed 12 to 15 bushels per acre.



AN ALKALI SPOT, GRAND FORKS AREA, NORTH DAKOTA.

Small areas are frequently encountered with from 1 to 3 per cent of alkali in the surface foot, although usually the alkali is below the surface foot and permits of the growing of wheat and barley.

A valley phase of the Fargo gravelly loam consists of from 1 to 6 inches of black, sometimes mucky, sandy loam, often containing small gravel, underlain to a depth of 2 feet by a gritty black or gray loam containing small pebbles up to one-half inch or so in diameter. This is in turn underlain to a depth of 6 feet by a gritty, stiff, mottled gray and yellow clay loam or clay, interspersed with small gravel and usually with small concretions of iron oxide. Sometimes the sixth foot, especially in the eastern part of the area, becomes a silty loam of the same material as the subsoil of the Miami black clay loam. Beds of crystalline gypsum are often found in this phase at any depth below the first foot. The surface, especially in the former estuaries of the old glacial lake, is often strewn with glacial boulders of granite, gneiss, limestone, and schist.

This phase is found in the western and middle parts of the area surveyed. It occupies swales between the beaches and the estuaries of the ancient lake. The latter position is principally found south and southeast of Ojata, where the soil sometimes is intersected by small beaches and ridges.

The areas of this phase of the soil are usually level, though, as before stated, they are often found in low places. Although standing water is on an average only from 4 to 6 feet below the surface, they were not swampy at the time the survey was made. A few of the natural swamps, especially southeast of Ojata, are of this soil type.

The condition of this soil could be considerably improved by artificial underdrainage, using the sloughs which frequently dissect the areas for the main drains or outlets.

There is but little alkali in the first 3 feet of soil in the area west of Larimore, but there is usually considerable in the subsoil. On the other hand the area in and around Ojata is badly impregnated with alkali, both in the surface soil and in the subsoil. This subject will be considered in the chapter on "Alkali in soils."

The area west of Larimore is well adapted to wheat, oats, barley, flax, and corn, but the area in and around Ojata is better adapted to hay and pasturage under present conditions, as there is generally too much alkali in the surface soil for profitable cultivation of the cereals, which make but an indifferent growth. A good crop of wild prairie grasses, including salt grass, was growing on this soil at the time the survey was made. Indeed, over the greater part of the area about Ojata it would be nearly impossible to say whether or not the soil was alkaline without making the chemical test. Grass knee-high was seen on soil containing over 1 per cent of alkali in the first 3 feet, with a uniform distribution.

The table on the following page shows the mechanical composition of the Fargo gravelly loam.

Mechanical analyses of Fargo gravelly loam.

[Fine earth.]

| No. | Locality. | Description. | Organic matter. | Gravel, 2 to 1 mm. | Coarse sand, 1 to 0.5 mm. | Medium sand, 0.5 to 0.25 mm. | Fine sand, 0.25 to 0.1 mm. | Very fine sand, 0.1 to 0.05 mm. | Silt, 0.05 to 0.005 mm. | Clay, 0.005 to 0.0001 mm. |
|------|---|--------------------------------------|-----------------|--------------------|---------------------------|------------------------------|----------------------------|---------------------------------|-------------------------|---------------------------|
| 7445 | SE. corner sec. 9, T. 150 N., R. 55 W. | Sandy loam, 0 to 12 inches. | P. ct. | P. ct. | P. ct. | P. ct. | P. ct. | P. ct. | P. ct. | P. ct. |
| | | | 7.30 | 1.48 | 4.64 | 5.62 | 13.76 | 8.30 | 42.60 | 22.96 |
| 7449 | SW. corner sec. 15, T. 151 N., R. 55 W. | Gravelly sandy loam, 0 to 12 inches. | 4.87 | 2.30 | 6.42 | 7.84 | 29.80 | 11.30 | 26.22 | 15.16 |
| 7447 | E. corner sec. 21, T. 151 N., R. 52 W. | Loam, 0 to 12 inches. | 3.92 | 1.72 | 4.34 | 3.76 | 9.94 | 15.10 | 46.86 | 18.20 |
| 7448 | Subsoil of 7447..... | Gravelly clay loam, 24 to 36 inches. | .34 | 2.28 | 4.36 | 4.00 | 10.62 | 10.40 | 47.20 | 20.78 |
| 7451 | Subsoil of 7449..... | Gritty loam, 48 to 60 inches. | 1.02 | 2.94 | 7.64 | 6.24 | 15.86 | 12.36 | 32.80 | 21.16 |
| 7450 |do | Gritty loam, 24 to 36 inches. | 2.80 | 3.74 | 6.34 | 5.92 | 21.06 | 9.94 | 26.62 | 26.26 |
| 7446 | Subsoil of 7445..... |do | 1.57 | 3.26 | 6.74 | 5.42 | 13.68 | 9.20 | 35.10 | 26.26 |

MIAMI SANDY LOAM.

The Miami sandy loam consists of from 1 to 2 feet of loose black sandy loam underlain to a depth of 3 feet by a gray sandy loam. This is in turn underlain by mottled gray and yellow sandy loam to a depth of 6 feet. Sometimes the sixth foot is yellow sand containing small concretions of iron oxide. Rarely the second foot grades into loam but in this case the sandy loam is found beneath it. In the southeast quarter of T. 150 N., R. 53 W., the soil has a fine silty sandy loam subsoil that extends from a depth of 3 feet to one of 6 feet.

This soil type is found on the higher-lying areas in the western and middle parts of the area, excepting the glacial-drift area, the typical soil being found in and around Larimore. The beaches, which generally consist of the same material as the surface, contain considerable gravel at a depth of 2 or 3 feet, and this coarser material often outcrops on top of the beaches. Some parts of these beaches, especially near the western limit of the area, closely resemble eskers. The large glacial boulders commonly found on the other types are usually absent from this one. The soil owes its origin mostly to wave action during the existence of the glacial lake.

The Miami sandy loam is well drained and free from alkali and is generally well adapted to wheat, oats, flax, and barley. Owing, however, to the light and loose texture of the surface soil of some of the areas a plentiful supply of rain is necessary to insure good crops. The beaches are generally too light and loose in texture and often too gravelly to be of any value for agriculture.

This is the only type in which gypsum beds were not found at some depth or other.

Below are given the mechanical analyses of this soil:

Mechanical analyses of Miami sandy loam.

| No. | Locality. | Description. | Organic matter. | Gravel, 2 to 1 mm. | | Coarse sand, 1 to 0.06 mm. | Medium sand, 0.06 to 0.25 mm. | Fine sand, 0.25 to 0.1 mm. | | Very fine sand, 0.1 to 0.06 mm. | Silt, 0.06 to 0.005 mm. | Clay, 0.005 to 0.0001 mm. |
|------|--|---------------------------------------|-----------------|--------------------|--------|----------------------------|-------------------------------|----------------------------|--------|---------------------------------|-------------------------|---------------------------|
| | | | | P. ct. | P. ct. | | | P. ct. | P. ct. | | | |
| 7452 | W. center sec. 23, T. 151 N., R. 54 W. | Sandy loam, 0 to 12 inches. | 2.79 | 0.76 | 3.86 | 6.88 | 56.32 | 6.38 | 18.94 | 5.90 | | |
| 7455 | Center NW. $\frac{1}{4}$ sec. 24, T. 151 N., R. 55 W. |do..... | 3.59 | .10 | 1.82 | 3.32 | 50.76 | 14.22 | 18.80 | 11.10 | | |
| 7453 | Subsoil of 7452..... | Sandy loam, 24 to 36 inches. | 1.22 | .64 | 3.90 | 7.60 | 68.94 | 5.58 | 5.52 | 7.02 | | |
| 7454 |do..... | Sandy loam, 48 to 60 inches. | .72 | 2.46 | 9.20 | 8.24 | 55.70 | 6.34 | 8.60 | 9.12 | | |
| 7456 | Subsoil of 7455..... | Heavy sandy loam, 24 to 36 inches. | .86 | .24 | .88 | 3.12 | 43.56 | 14.32 | 14.54 | 22.60 | | |

FARGO LOAM.

The Fargo loam consists of about 6 inches of black sandy loam of the same character as the surface soil of the Miami sandy loam, underlain with black loam or light clay loam to a depth of 1½ feet. Beneath this, to a depth of 2 feet 9 inches, is a fine gray, sometimes silty, loam containing no appreciable amount of grit and very much like the corresponding section of the Miami black clay loam. This stratum is in turn underlain to a depth of 6 feet with a fine sandy, usually silty, loam, which is generally mottled, contains small concretions of iron oxide, and is of a gray and yellow color below the fourth foot.

Small beds of gypsum often occur in the second foot, but owing no doubt to the light subsoil there is usually no excess of alkali in the first 3 feet.

The drainage of this soil is usually good, and the type is almost an ideal one for an alkali district, as the light subsoil allows the alkali to be carried away by the underground water, while the surface soil is heavy enough to retain moisture well.

This soil occupies the slight depressions and shallow swales found in the Miami sandy loam area, and owes its origin partly to transportation of the finer particles from the higher lying sandy loam areas, although chiefly to lacustrine deposit during the early period of the recession of the glacial lake.

The soil is well adapted to wheat, oats, flax, barley, and corn. As its ability to retain moisture is greater than that of the lighter soils it withstands drought better, and crops are somewhat surer on this account.

The following table shows the mechanical analyses of typical samples of this soil:

Mechanical analyses of Fargo loam.

| No. | Locality. | Description. | Organic matter. | Gravel, 2 to 1 mm. | Coarse sand, 1 to 0.5 mm. | Medium sand, 0.5 to 0.25 mm. | Fine sand, 0.25 to 0.1 mm. | Very fine sand, 0.1 to 0.06 mm. | Silt, 0.05 to 0.005 mm. | Clay, 0.005 to 0.0001 mm. |
|------|--|------------------------------------|-----------------|--------------------|---------------------------|------------------------------|----------------------------|---------------------------------|-------------------------|---------------------------|
| 7457 | $\frac{1}{4}$ mile E. of NW. corner sec. 15, T. 150 N., R. 54 W. | Light loam, 0 to 12 inches. | P. ct. 6.28 | P. ct. Tr. | P. ct. 1.60 | P. ct. 3.30 | P. ct. 39.74 | P. ct. 15.74 | P. ct. 25.50 | P. ct. 13.54 |
| 7459 | Subsoil of 7457..... | Light sandy loam, 48 to 60 inches. | .79 | 0.20 | .94 | 2.44 | 50.50 | 20.24 | 14.66 | 10.72 |
| 7458 |do | Loam, 24 to 36 inches | 1.60 | .00 | .98 | 3.14 | 40.38 | 15.74 | 16.78 | 22.26 |

MIAMI LOAM.

The Miami loam consists of from 1 to 2 feet of black to brown sandy loam of the same texture as the material composing the surface soil of the Miami sandy loam. This material, without change in texture, grades into a yellow-colored soil beneath which occurs about 1 foot of gray or white gritty loam, often containing small gravel. This is in turn underlain to a depth of 6 feet with a mottled gray and yellow stiff, gritty loam or clay loam, containing a large proportion of small gravel. Usually small concretions of iron oxide are present in the soil below the fourth foot. This subsoil is much like the corresponding section of Fargo gravelly loam, and, like it, carries local beds of gypsum.

There are rarely large enough areas containing excessive amounts of alkali in the first 3 feet of the soil of this type to be indicated on a map of the scale used; that is, there is generally less than the minimum limit of 0.20 per cent. The subsoil, however, usually contains some alkali, and often the amount is considerable.

This soil is found on the slopes of the eastern beaches of the old lake and in intervening areas, being typically developed at Emerado. The sandy loam surface is due to transportation and deposition of material carried over the beaches by the water during the recession of the lake. Some of the areas of the type owe their origin to transportation of sandy loam and sand from the top of the beaches into the swales between them, the sandy loam being really a covering over the Fargo gravelly loam.

The typical areas of this type are well adapted to wheat, oats, barley, millet, and flax, though the lower-lying areas of the type, where the alkaline subsoil is near the surface, do not produce very good crops.

The following table gives mechanical analyses of this soil:

Mechanical analyses of Miami loam.

| No. | Locality. | Description. | Organic matter. | Gravel, 2 to 1 mm. | Coarse sand, 1 to 0.5 mm. | Medium sand, 0.5 to 0.25 mm. | Fine sand, 0.25 to 0.1 mm. | Very fine sand, 0.1 to 0.05 mm. | Silt, 0.05 to 0.005 mm. | Clay, 0.005 to 0.0001 mm. |
|------|---|-------------------------------------|-----------------|--------------------|---------------------------|------------------------------|----------------------------|---------------------------------|-------------------------|---------------------------|
| 7437 | $\frac{1}{4}$ mile S. of NE. corner sec. 2, T. 151 N., R. 52 W. | Sandy loam, 0 to 18 inches. | P. ct. 5.74 | P. ct. 1.68 | P. ct. 4.74 | P. ct. 9.12 | P. ct. 12.16 | P. ct. 20.64 | P. ct. 41.12 | P. ct. 10.54 |
| 7438 | Subsoil of 7437. | Loam or clay loam, 48 to 60 inches. | .47 | 2.50 | 3.90 | 3.96 | 10.74 | 9.34 | 48.14 | 21.42 |

MIAMI BLACK CLAY LOAM.

The Miami black clay loam consists of from 1 inch to 4 or 5 inches of muck or mucky loam underlain with black loam, often of a silty texture, to a depth of from 1 to 2 feet. Beneath this is about a foot of fine gray, usually silty, loam that nearly always grades into yellow silty loam at about 3 feet below the surface. This is in turn underlain to a depth of 6 feet with a mottled gray and yellow silty loam, sometimes becoming a silty clay loam in the fifth or sixth foot. Almost invariably small concretions of iron oxide occur in the soil below the third foot. It is this iron that gives the soil its usual yellow color when a depth beyond the influence of dissolved organic matter is reached. The type is very fine in texture and usually does not contain a noticeable amount of sand. Local beds of crystalline gypsum often occur, and are found at any depth in the profile.

For a distance of several miles west of Red River there is in the surface 3 feet of the Miami black clay loam very little alkali, but farther west, as far as the type has been mapped, and especially around Ojata, where the natural drainage is poor, the amount of alkali is considerable. Black alkali was almost invariably found in both the surface soil and subsoil, the quantity varying from a trace to 0.05 per cent in the surface foot, and usually a little less in the subsoil. The black alkali is, of course, not found in areas with free gypsum beds. There was also very often less than 0.20 per cent of soluble salt in the first 3 feet in these places.

Excepting the alkali areas, the Miami black clay loam is generally recognized as being a fine soil for wheat, oats, barley, and flax. The type very well withstands moderate drought, the subsoil being always in fine, moist condition. It would be an excellent soil for celery in seasons of good rainfall.

The area over which this soil occurs is very level, broken only by a few shallow creek depressions which do not at all interfere with cultivation. (See Pl. XXXV.)

This soil is a lacustrine deposit, and is the only type in the area that has not been modified by other action since the original deposition.

The following table shows the texture of this soil:

Mechanical analyses of Miami black clay loam.

| No. | Locality. | Description. | Organic matter. | Gravel, 2 to 1 mm. | Coarse sand, 1 to 0.5 mm. | Medium sand, 0.5 to 0.25 mm. | Fine sand, 0.25 to 0.1 mm. | Very fine sand, 0.1 to 0.05 mm. | Silt, 0.05 to 0.005 mm. | Clay, 0.005 to 0.0001 mm. |
|------|--|------------------------------|-----------------|--------------------|---------------------------|------------------------------|----------------------------|---------------------------------|-------------------------|---------------------------|
| 7442 | W. center sec. 36, T. 151 N., R. 51 W. | Loam, 0 to 12 inches. | P. ct. 5.67 | P. ct. 0.00 | P. ct. 0.20 | P. ct. 0.20 | P. ct. 1.66 | P. ct. 17.10 | P. ct. 75.04 | P. ct. 4.94 |
| 7439 | N. center sec. 91, T. 151 N., R. 52 W. |do..... | 4.02 | .36 | 1.14 | 1.22 | 3.56 | 5.70 | 64.78 | 22.88 |
| 7443 | Subsoil of 7442..... | Silty loam, 24 to 36 inches. | .65 | 12 | .54 | .40 | .70 | 9.36 | 83.82 | 4.18 |
| 7444 |do..... | Silty loam, 48 to 60 inches. | .46 | .00 | .36 | .30 | .56 | 3.22 | 79.78 | 14.82 |
| 7440 | Subsoil of 7439..... | Silty loam, 24 to 36 inches. | .79 | .20 | .72 | .88 | .68 | 4.06 | 77.42 | 16.34 |
| 7441 |do..... | Silty loam, 48 to 60 inches. | .53 | .16 | .60 | .50 | 1.00 | 2.70 | 73.12 | 21.68 |

MUCK.

The Muck soil is found in many places in different parts of the area, the individual areas varying in size from an acre or less to about 1 square mile. The type consists of from 1 to 3 feet of muck, underlain by sandy loam or sand or, rarely, by loam. This is in turn underlain by sandy loam to a depth of 6 feet.

Muck is found in local depressions, such as kettle holes and swales, and generally along the creek courses and in swamps. It is due to gradual accumulation and decomposition of organic matter resulting from the rank grasses which in this area appear to be about the only vegetation growing in these swampy places. In the spring of the year the areas are usually wet and swampy, but during summer they become dry enough to allow the cutting of the grasses for hay.

No alkali exists in this type, its absence being chiefly due to the light subsoil, as, aside from percolation downward, these areas are usually poorly drained.

UNDERGROUND WATER.

A map showing the depth to underground water at the time the survey was made accompanies this report (Pl. XXXVIII).

No general relation seemed to exist between the salt content of the soil and the water table, except where the latter was within 3 feet or so of the surface, when there was generally a noticeable increase of salt in the surface foot of soil.

The following table shows the results of field analyses of well waters in all parts of the area. With but few exceptions the shallow wells contained less soluble salts than the deeper, and especially the flowing wells. The alkali content of the last ranged from 420 to 1,430 parts of soluble salt per 100,000 parts of water, the salts consisting mostly of chlorides, with sulphates second. The deep and the flowing wells generally contain less of the bicarbonates than the shallow wells.

Chemical analyses of well waters.

| No. of sample. | Location. | Depth in feet. | Parts of salt per 100,000. | | | |
|----------------|--|----------------|----------------------------|---------------|------------|-------------------------|
| | | | Total salt content. | Bicarbonates. | Chlorides. | Sulphates. ^a |
| 14 | ½ mile E. of SW. corner sec. 8, T. 151 N., R. 51 W. | ..... | 250 | 49 | 12 | 189 |
| 15 | N. center sec. 7, T. 151 N., R. 50 W. | (b) | 540 | 42 | 276 | 212 |
| 52 | NE. corner sec. 16, T. 151 N., R. 50 W. | (b) | 420 | 38 | 260 | 122 |
| 524 | Same place as sample 52 | 5 | 55 | (c) | (c) | (c) |
| 59 | SW. corner sec. 2, T. 151 N., R. 50 W. | 6 | 180 | 89 | 9 | 32 |
| 80 | ½ mile N. of SW. corner sec. 34, T. 151 N., R. 50 W. | 75 | 90 | (c) | (c) | (c) |
| 81 | ½ mile W. of SE. corner sec. 34, T. 151 N., R. 50 W. | 7 | 40 | (c) | (c) | (c) |
| 91 | ½ mile W. of NE. corner sec. 11, T. 150 N., R. 50 W. | ..... | 130 | 67 | 5 | 58 |
| 93 | W. center sec. 3, T. 150 N., R. 50 W. | ..... | 90 | (c) | (c) | (c) |
| 106 | NE. corner sec. 32, T. 151 N., R. 50 W. | 7 | 55 | (c) | (c) | (c) |
| 171 | S. center sec. 6, T. 150 N., R. 54 W. | 12 | 170 | 63 | Tr. | 107 |
| 178 | N. center sec. 11, T. 151 N., R. 55 W. | 16 | 28 | (c) | (c) | (c) |
| 183 | NE. corner sec. 4, T. 151 N., R. 55 W. | 15 | 60 | 52 | 7 | None. |
| 190 | ½ mile E. of SW. corner sec. 17, T. 151 N., R. 55 W. | 40 | 250 | 53 | 64 | 133 |
| 209 | NE. corner sec. 33, T. 151 N., R. 55 W. | 18 | 60 | 58 | 3 | None. |
| 215 | NE. corner sec. 29, T. 151 N., R. 55 W. | 15 | 360 | 50 | 58 | 252 |
| 217 | NE. corner sec. 31, T. 151 N., R. 55 W. | 9 | 320 | 50 | 58 | 212 |
| 227 | SW. corner sec. 33, T. 151 N., R. 55 W. | 10 | 170 | 67 | 21 | 82 |
| 230 | ½ mile E. of SW. corner sec. 5, T. 150 N., R. 55 W. | 60 | 180 | 71 | 21 | 88 |
| 245 | SE. corner sec. 34, T. 151 N., R. 55 W. | ..... | 220 | 60 | 21 | 189 |
| 316 | SE. corner sec. 25, T. 150 N., R. 55 W. | 8 | 135 | 58 | 3 | 74 |
| 334 | SE. corner sec. 26, T. 151 N., R. 55 W. | 10 | 135 | 78 | 12 | 45 |
| 354 | ½ mile N. of SE. corner sec. 1, T. 151 N., R. 54 W. | ..... | 465 | 87 | 12 | 366 |
| 374 | E. center sec. 12, T. 151 N., R. 54 W. | 150 | 560 | 63 | 7 | 490 |
| 397 | S. center sec. 23, T. 151 N., R. 53 W. | 9 | 180 | 73 | 23 | None. |
| 420 | ½ mile S. of NW. corner sec. 4, T. 150 N., R. 53 W. | 9 | 250 | 55 | Tr. | 195 |
| 450 | N. center sec. 11, T. 151 N., R. 52 W. | 9 | 110 | 53 | 63 | None. |
| 456 | ½ mile W. of NE. corner sec. 1, T. 151 N., R. 52 W. | (b) | 490 | 42 | 290 | 158 |
| 473 | S. center sec. 16, T. 151 N., R. 52 W. | 4 | 340 | 52 | 16 | 272 |
| 493 | SE. corner sec. 24, T. 151 N., R. 52 W. | b33 | 560 | 42 | 302 | 216 |
| 335 | SE. corner sec. 26, T. 151 N., R. 53 W. | 80 | 130 | 80 | 12 | 38 |
| 519 | SE. corner sec. 27, T. 151 N., R. 52 W. | b130 | 520 | 78 | 358 | 89 |
| 529 | N. center sec. 35, T. 151 N., R. 52 W. | b44 | 420 | 58 | 202 | 165 |
| 533 | ½ mile W. of SE. corner sec. 11, T. 151 N., R. 52 W. | (b) | 430 | 50 | 813 | 567 |
| 536 | NE. corner sec. 13, T. 151 N., R. 52 W. | 6 | 70 | 50 | 14 | None. |
| 564 | SW. corner sec. 30, T. 151 N., R. 51 W. | b135 | 660 | 45 | 441 | 174 |
| 578 | N. center sec. 1, T. 151 N., R. 51 W. | ..... | 720 | 50 | 346 | 324 |

^aSulphates computed by taking the difference between total salt content and bicarbonates and chlorides.

^bFlowing.

^cQuantity not determined.

ALKALI IN SOILS.

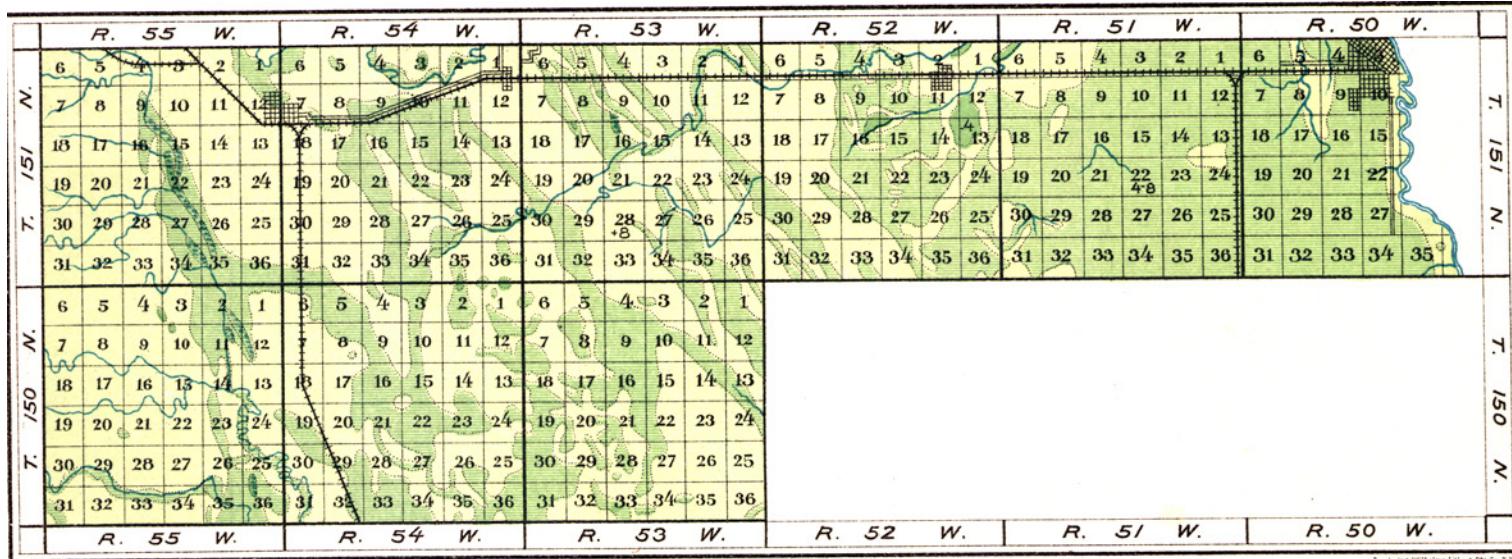
The map (Pl. XXXVII), showing the alkali in the soil, departs from the general rule of such maps previously made for areas lying in irrigated and arid regions in one particular, viz., it is based upon the mean amount of salts in the first 3 feet of soil instead of upon the mean in the first 6 feet. The difference in climatic conditions and the fact that shallow-rooted crops form almost exclusively the agriculture of the area made it seem unnecessary to use the more extended profile in this case. It is even thought that a map based on the shallower borings will be of greater value than one where the deeper subsoil was taken into the calculations.

In the Grand Forks area there is generally enough precipitation to prevent the salt in the subsoil from lodging permanently in the surface soil through capillary action, and the roots of the crops commonly grown do not usually, perhaps never, reach deeper than 3 feet. The fact that alkali below this depth, or even at 2 or 3 feet, can have little or no effect on the crop growth was conclusively proved by the condition of the crops seen during the survey. Irrigation is not practiced in the area, and probably never will be extensively practiced, so that the vertical distribution of the salts will not, as in other alkali areas, be affected artificially, and as long as the present method of farming continues in the area there seems no probability that the salts in the subsoil will rise.

A number of determinations were made, however, to depths of 6 and of 8 feet, for the purpose of studying the vertical distribution of the salts in the subsoil. No alkali was found in the Miami sandy loam, even at a depth of 6 feet, and not enough in the first 3 feet of Fargo gravelly loam to map, though considerable quantities were present in the subsoil. The conditions in the case of the Miami loam were similar to those of the Fargo gravelly loam, as typically developed, and in these two types alkali would have been much more general had the salt map been based on the mean of 6-foot borings instead of 3-foot borings, and the conditions would have apparently been much worse than they actually are. Very little alkali was found in the Fargo loam in the first 3 feet, and none was found in the subsoil, as this was much lighter in texture than the soil.

The two types containing injurious amounts of alkali in the first 3 feet, as well as in the deeper soil, are the Miami black clay loam and the valley phase of the Fargo gravelly loam. As shown by the alkali map, the greater part of these two soils carry an average of more than 0.20 per cent of soluble salt at soil saturation in the first 3 feet, and if the map had been constructed to 6 feet the conditions would have appeared worse in practically all parts of these areas.

The worst alkali conditions were found in T. 151 N., Rs. 51 and 52

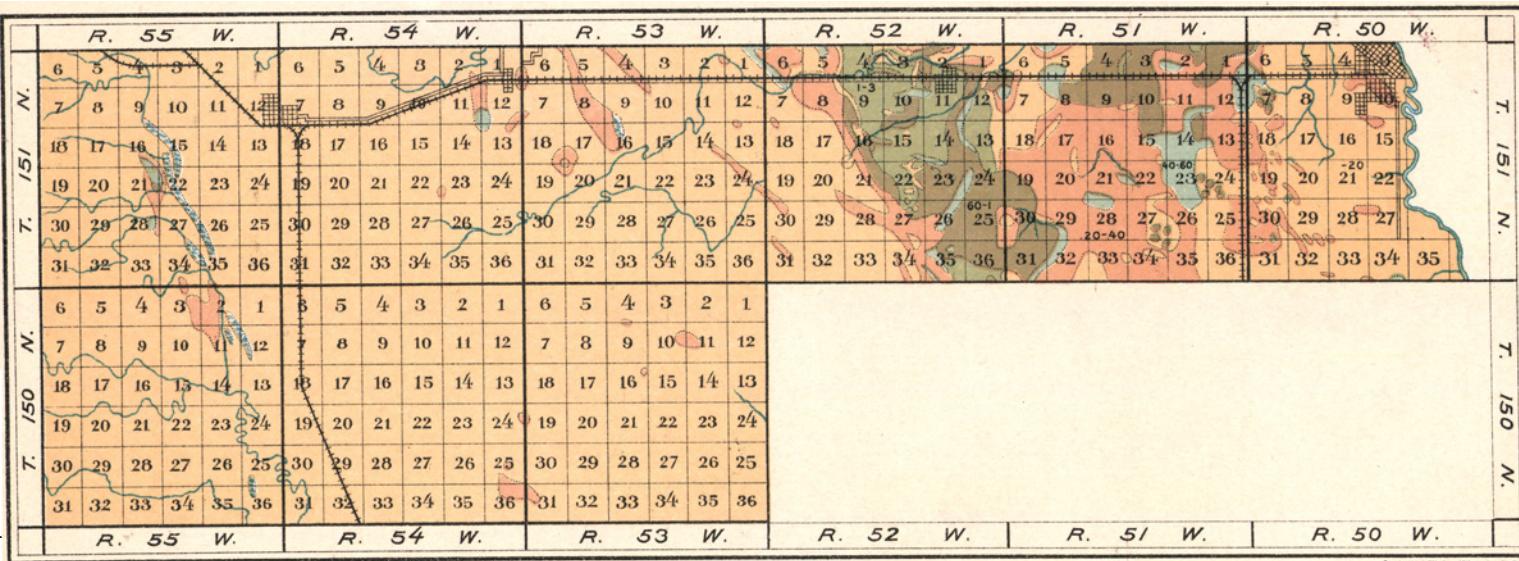


UNDERGROUND WATER MAP, GRAND FORKS SHEET.

-4
Water less than
4 feet below surface.

4-8
Water 4 to 8 feet
below surface.

+8
Water over 8 feet
below surface.



ALKALI MAP GRAND FORKS SHEET.

-20

Less than
20 per cent

.20-40

From 20 to
40 percent

40 - 60

From .40 to
.60 per cent

.60 - 1.

From 60 to
1 per cent

1. -3.

From 1. to
3. per cent

W. This includes most of the strictly lacustrine deposit soils, as the surface soils west of Emerado have been modified by secondary deposits since the lacustrine subsoil was laid down. (See Pl. XXXVI.)

Two ways suggest themselves in which the alkali may have originated. It may have reached the surface by the capillary movement of the salt-carrying, deep-seated waters percolating the underlying drift or Cretaceous shales, assisted by the natural pressure to which these substrata are subjected, or it may have been deposited with the lacustrine material either by being in solution in the lake water, which may have been concentrated, or as being originally in the soil washed into the lake. It does not appear that the lake water ever reached a high state of concentration, and this theory is hardly likely, the origin of the lake considered.

The soil borings can be of little value in determining the origin, except so far as they show the constitution of the alkali. Considerable information on this point is obtained by a study of the table of analyses of well waters given on a preceding page. It is undoubtedly fair to assume that the relation of the salt constituents in the well waters agrees approximately with the solution in the soil from which the water is derived.

The chemical analysis of the standardization solution made in the Bureau laboratory conclusively shows the great preponderance of the acids to be sulphates, these constituting, in fact, more than half of the total amount of salts, with chlorides second, but by no means in large quantities. This solution represents all depths of alkali soils from surface crusts to soil 6 feet below the surface. The various titrations made on soil samples in all parts of the area by the party in the field also brought out the fact that sulphates were generally in excess of any other salt. An inspection of the table of well-water analyses will show that the shallower wells, with but very few exceptions, show sulphates greatly in excess of chlorides.

As no method for the determination of sulphates quantitatively in the field has been devised, these were estimated by difference. The total amount of salt, the chlorides, the carbonates, and the bicarbonates were determined electrically and volumetrically, and it was assumed that the difference between the total amount of salt and the sum of the other constituents mentioned was equal to the sulphates. The results of this method are not, of course, strictly accurate, but are sufficiently so for the purpose of discussion, as no other salts were reported in the complete chemical analyses made in the laboratories.

By referring to the above-mentioned table it will be seen that the chlorides and sulphates occur in altogether different relation in the deeper wells, and especially in the flowing wells, than they do in the shallower wells, i. e., wells with a depth of 20 feet or so. There are

apparently exceptions, as for instance in Nos. 230 and 335, but as the surface water was not excluded from the deeper seated strata these are of no consequence. The chlorides are in every instance in excess of the sulphates in these deep wells, while in the shallower wells the sulphates are largely in excess. Considered along with this that beds of sulphates, especially gypsum, are quite numerous in the lacustrine deposit and distributed over the entire lacustrine area—Miami black clay loam and valley phase of the Fargo gravelly loam—one can not but conclude that the alkali in the alluvial area in the surface soils was deposited with the soils at the time these were laid down in the lake, and that the alkali water from the deeper and flowing wells belongs to another formation, probably the underlying Cretaceous shales.

With but few exceptions the quantity of salt was found to increase downward. The maximum found was about 3 per cent in the dry soil, and in the worse alkali districts this quantity was found at from 3 to 6 feet. No maximum was found in any one particular foot section, but when once the 3 per cent was reached there was no diminution.

Black alkali was very often, in fact generally, found, even in the presence of small amounts of sulphates, in both soil and subsoil. It was particularly likely to occur in the surface foot, the amounts varying from a trace to 0.07 per cent, though this latter figure was reached in but one place. As much as 0.05 per cent was found in a number of places, but the distribution was not sufficiently extensive or general to warrant the construction of a separate black alkali map.

Good crops of grain, flax, and millet were often found growing on the alkali soils, even where the average amount of salt in the first 3 feet ranged from 1 to 3 per cent. This was due often to the unequal vertical distribution of the alkali, the surface foot carrying but a small part of the total amount. In arid regions such amounts of alkali would with certainty kill any but the most resistant salt grasses, and some areas where most vegetation had succumbed were found in the area surveyed, while in the worst alkali district, in and around Ojata, bare spots were common, these containing a surface deposit of alkali, where even salt grasses and alkali weeds could not exist. However, very fair crops were found to be growing even where the surface foot carried what would usually be considered excessive amounts of salt for agricultural crops.

The table on the following page, while not intended at all to define the exact salt conditions under which crops will or will not grow, shows at least conditions as found in the area surveyed.

Table showing the relation of the condition of growing crops to the percentage of alkali in the first foot of soil in the Grand Forks area.

| Crops. | Condition. | | | |
|-------------------------------------|------------|------------|------------|-----------|
| | Good crop. | Fair crop. | Poor crop. | Killed. |
| | Per cent. | Per cent. | Per cent. | Per cent. |
| Wheat..... | { 0.30 | ..... | ..... | 0.56 |
| | .39 | ..... | ..... | .76 |
| | .46 | ..... | ..... | ..... |
| Oats..... | { .39 | .58 | .63 | ..... |
| | .46 | ..... | .84 | ..... |
| | .51 | ..... | ..... | ..... |
| Barley..... | { .31 | .44 | .70 | ..... |
| | .43 | .46 | ..... | ..... |
| | | | | |
| Flax..... | { .32 | .37 | .52 | .50 |
| | .38 | .55 | .64 | .86 |
| | | | | |
| Prairie grass and salt grasses..... | { 1.16 | 1.50 | ..... | ..... |
| | 1.20 | 2.00 | ..... | ..... |

There are, of course, different crop conditions with the same salt content in the surface foot of soil, as many factors enter into discussion, such as late or early seeding, presence or absence of favorable proportion of moisture in the soil, etc. As these conditions were found in the fall of the year when the crops were matured there can be no doubt about the observations. It should also be kept in mind that in every instance the salt content increased in lower depths, the third foot section carrying more than 1 per cent of alkali in some cases where good crops were growing.

There is but one way to reclaim the alkali flats so that they will grow agricultural crops profitably, viz, by draining them artificially. The subsoil is too heavy in all places to accomplish drainage otherwise. The alkali area in and around Ojata could be drained into the swamps and shallower creek beds or sloughs found there. It would, however, involve quite an outlay of capital, and under present agricultural conditions would probably not be profitable. The drains, however, would not need to be laid as deep as in the more arid regions, as the greater rainfall washes the salts down from the surface and it is not necessary to control accumulation through evaporation. These alkali flats are, however, valuable even in their present condition, as the native grasses growing on the greater part of them make very good hay when properly cured.

Chemical analyses of alkali soils and crusts.

| Constituent. | 7460, $\frac{1}{4}$ mile E. of University; alkali crust. | | 746L, $\frac{1}{4}$ mile W. of NE. corner sec. 12, T. 151 N., R. 51 W., alkali crust. | | 7462, $\frac{1}{4}$ mile W. of NE. corner sec. 12, T. 151 N., R. 51 W., subsoil 12 to 36 inches. | | 7463, $\frac{1}{4}$ mile S. of NW. corner sec. 6, T. 151 N., R. 50 W., subsoil 4 to 6 feet. | | 7464, $\frac{1}{4}$ mile E. of SW. corner sec. 22, T. 151 N., R. 50 W., alkali crust. | | 7465, $\frac{1}{4}$ mile S. of NW. corner sec. 10, T. 151 N., R. 50 W., alkali crust. | | 7466, West center sec. 31, T. 150 N., R. 55 W., subsoil 12 to 36 inches. | |
|---|--|---------|---|---------|--|---------|---|---------|---|---------|---|---------|--|---------|
| Ions: | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. | Per ct. |
| Calcium (Ca)..... | 6.74 | 5.83 | 16.82 | 13.31 | 1.76 | 7.34 | | | | | | | | 24.56 |
| Magnesium (Mg)..... | 14.34 | 10.74 | 7.12 | 5.89 | .81 | 14.24 | | | | | | | | 1.55 |
| Sodium (Na)..... | 1.13 | 10.69 | 1.15 | 1.96 | 28.44 | 1.13 | | | | | | | | .94 |
| Potassium (K)..... | 1.42 | .95 | 2.88 | 11.44 | 1.00 | .59 | | | | | | | | 1.55 |
| Sulphuric acid (SO_4)..... | 73.94 | 47.12 | 59.71 | 41.98 | 65.49 | 73.99 | | | | | | | | 68.94 |
| Chlorine (Cl)..... | .77 | 23.59 | 9.16 | 20.11 | .64 | 1.56 | | | | | | | | .64 |
| Bicarbonic acid (HCO_3)..... | 1.66 | 1.08 | 3.16 | 5.36 | 1.86 | 1.15 | | | | | | | | 1.82 |
| Conventional combinations: | | | | | | | | | | | | | | |
| Calcium sulphate (CaSO_4)..... | 22.28 | 19.82 | 57.10 | 26.45 | 5.97 | 24.97 | | | | | | | | 83.46 |
| Magnesium sulphate (CaSO_4)..... | 70.99 | 41.49 | 24.31 | 29.22 | 4.04 | 70.64 | | | | | | | | 9.99 |
| Sodium sulphate (Na_2SO_4)..... | 2.55 | ..... | ..... | ..... | 85.91 | ..... |  |  |  |  |  |  |  | 2.35 |
| Potassium chloride (KCl)..... | 1.63 | 1.81 | 5.50 | 21.81 | 1.35 | 1.71 | | | | | | | | 1.36 |
| Sodium bicarbonate (NaHCO_3)..... | 1.09 | 1.49 | 4.29 | ..... | 1.99 | 1.58 | | | | | | | | .72 |
| Magnesium chloride (MgCl_2)..... | 9.24 | 8.80 | ..... | ..... | ..... | 1.70 |  |  |  |  |  |  |  | ..... |
| Sodium chloride (NaCl)..... | 26.15 | ..... | ..... | 15.19 | ..... | ..... |  |  |  |  |  |  |  | ..... |
| Calcium chloride (CaCl_2)..... | ..... | ..... | ..... | ..... | ..... | ..... |  |  |  |  |  |  |  | ..... |
| Per cent soluble..... | 10.79 | 15.50 | 3.82 | 2.24 | 12.96 | 12.52 | | | | | | | | 5.27 |

Part of the sodium, varying from 0.24 per cent in sample 7463 to 2.17 per cent in sample 7460, was probably in combination with organic acids, and is therefore not shown in the foregoing table.

AGRICULTURAL METHODS.

The principal products grown are wheat, oats, barley, flax, millet, and hay. Some vegetables are produced for the market, but not much importance is given to this branch of farming. The hay lands are confined chiefly to the low-lying and naturally swampy areas. Wheat is by far the most important crop grown, and the product is very favorably known all over the country for its quality. The wheat is all spring sown and of the hard variety. In 1902 there was a greater area in the county devoted to wheat than to all other crops combined. In the same year flax was second in acreage, it having been grown much more generally that year than ever before. The increase that year was no doubt partly due to a desire to carry on more diversified farming, but also largely to the fact that the season was quite late and much of the land not dry enough in time to allow wheat or oats to mature. Millet was likewise grown more largely in 1902 than in any other year, which was also mainly due to a late spring. These two

crops need less time to mature than do the cereals, and hence they are sometimes used as emergency crops.

Flax, however, is generally conceded to be an unprofitable crop to grow on the same piece of land for more than two successive years, owing to a peculiar disease known as "flax wilt." The trouble is due to a fungus which appears to be introduced with the seed. When affected the plants turn yellow and partly wilt, and are considerably stunted in growth. If by chance they mature—which a badly affected plant does not—the seed is smaller than the average flaxseed and of a very inferior quality. There seems to be no remedy yet discovered for the disease, and farmers are recommended by the experiment stations to take great care in selecting their seed and to treat it with formaldehyde. The crop is grown almost exclusively for the seed, nothing being as yet done with the fiber excepting a small amount used at Fargo for making hemp. Plans are being seriously considered, however, for putting in machinery at that place (the plant now is small) which would utilize more of the straw and make the industry more general.

There is but little systematic rotation of crops practiced. A number of instances were met with where farmers had planted wheat for eighteen or twenty years without any other crop as alternate, the only break in the scheme being two or three years of summer fallowing. The effect of such constant cropping is quite readily noticed in some parts of the area, though much of the land continues to yield apparently as good crops as ever. When land is considered in need of "rest" it is generally summer fallowed. A decidedly better plan would be to alternate with hoed crops of some kind, but as the farms are generally extensive in area it does not seem to be considered worth while to expend the labor necessary to the production of such crops. More diversified farming could, however, be profitably introduced. Similarly little attention is paid to adaptation of crops to soils, any crop being planted on any kind of land.

Plowing is generally done in the fall, often before the grain is thrashed. This enables the seeding of the land to be done earlier in the spring than when plowing is left until spring, and this is an important matter on account of the shortness of the growing season. It is also a good practice in that it leaves the soil in a better condition for nourishing the next year's crop, as the weathering processes going on during the winter materially increase the available plant food. Especially is this true of the heavier soils.

The amount of seed sown to the acre varies widely, differing with the soil conditions and individual opinion. Any quantity from $1\frac{1}{2}$ to 3 bushels of wheat per acre is sown, and adherents of both extremes claim the better results. Certain it is, however, that more seed is needed in late sowing than in early sowing, in order that too much

stooling may be prevented and the crop forced to maturity as early as possible.

Grain harvesting is done altogether with the binder, and the thrashing is done by steam power. Usually the grain is not stacked, but is hauled direct from the shock to the thrasher. Considerable time, trouble, and expense are thus saved; but there is a slight loss attending this method, as wheat, especially, will usually sell a grade better if allowed to pass through the "sweating" process in the stack. It is generally considered, however, that the higher price received is not sufficient to warrant the trouble and expense of stacking.

The yields vary quite widely in different parts of the area, even on the same soil types, the variation depending on a number of factors. It is considered by unprejudiced observers that the average yield per acre is about 12 or 15 bushels of wheat, and this is probably a low enough figure. Forty bushels per acre have been raised with favorable circumstances. Barley yields, on the average, from 25 to 30 bushels, and oats from 35 to 40 bushels per acre. Flax, which is becoming an important crop, averages about 15 bushels per acre. As before mentioned, this crop does better on land that has not been seeded to flax for a number of years. An interesting case was met with in the area, where a piece of land had yielded 25 bushels per acre the first year—a big crop—20 bushels the second, 15 bushels the third, and about 12 to 15 bushels the fourth year. This, however, was on a choice piece of land, and where good care had been given the crops.

Very little fruit has yet been raised or attempted to be raised in the county, the climate being too severe for any but the most hardy sorts.

AGRICULTURAL CONDITIONS.

The agricultural conditions of the State at large have improved greatly and in almost every respect during the last decade. In that time the cultivated area and the number of farms have increased nearly 100 per cent, the acreage per farm has increased from 277 to 343 acres, and the value of farm lands, improvements, buildings, live stock, etc., has almost doubled.

The number of acres in farms in Grand Forks County in 1900 was 861,872. There were 2,368 farms. The average size of farms was 364 acres, and the average value of each, exclusive of buildings and improvements, was \$6,327. About 87 per cent of the farm land in the county is improved, and more is constantly being brought under cultivation. Generally speaking, the buildings and improvements are good, especially on the better lands, and the farmers are well supplied with the necessary live stock and implements for the successful operation of their farms.

The population of Grand Forks County is composed almost entirely of the farming class, and little interest is taken in stock raising except

as an adjunct to the economical operation of the farm. The proportion of the farmers of Grand Forks County owning farms can not be definitely stated, but for the whole State 91.5 per cent of the farms are operated by the owners and 7.2 per cent are operated by share tenants. This would probably be a very fair estimate of the conditions of tenure in the county. Some of the farms classed as operated by the owners, especially the larger farms, are in charge of managers appointed by the owners. The managers have general supervision of affairs and receive a fixed remuneration for their services. Quite often farms are operated by the owners and tenants in conjunction, the tenants receiving a share of the products.

Considerable labor is hired during the busy seasons of the year, and especially at harvest time. This being temporary employment, the laborer is paid considerably more than where the service is permanent, \$2.50 to \$3 per day for single hands being quite common, the work being shocking grain, assisting in thrashing, plowing, etc. Labor by the month or year is paid much less. According to a report of the county auditor, there were employed on the farms of the county, in 1901, 1,675 male and 347 female employees. According to the same authority, the average wages paid were \$24.25 and \$13 per month, respectively. There is very little colored help employed in the county.

The transportation facilities of the county are good. The main line of the Great Northern passes through the area from east to west, and a number of branches of this system radiate from Larimore and Grand Forks. The Northern Pacific system also touches the area, passing through Grand Forks.

Along the railroads, at frequent intervals and convenient points, there are small stations, each with from one to half a dozen elevators for storing products temporarily to await shipment. Few farmers have granaries of their own, but deliver their grain to the elevators immediately after it is thrashed, thus usually disposing of it at a lower price than could be obtained later in the year. But as the country is practically new and as many of the farmers have had to pay for their land in yearly payments, many of them are not yet in condition to hold their crops.

A prominent feature of the agriculture of the county is the operation of large farms. These frequently range between 1,000 and 5,000 acres, and in one—the largest in the county, and reported to be the largest grain farm in the world—11,000 acres were sown to crops in 1902. A movement is on foot, however, to have this place divided up into quarter sections and sold to colonists. This would introduce a more diversified farming, dairying, etc., and would be a good thing for the county. Some of the other owners of large farms are seriously considering doing the same thing, and better agricultural conditions will soon obtain if the plan is carried out.

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